
PLANNING & MANAGEMENT CONSULTANTS, LTD.
PROFILE AND QUALIFICATIONS

INTEGRATED WATER DEMAND AND SUPPLY PLANNING
FOR
WATER UTILITIES

- X *Integrated Resources Planning*
- X *Water Use Forecasting*
- X *Water Conservation Program Planning*
- X *Water Conservation Program Evaluation*
- X *Specialized Water Use Studies*
- X *Drought Contingency Planning*
- X *Public Utility Pricing*
- X *Sampling and Survey Research Methods*
- X *Specialized Training and Workshops*

March 2000

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Planning and Management Consultants, Ltd. (PMCL), of Carbondale, Illinois, was founded in 1976 and is a qualified small business enterprise (SBE) that is 100 percent employee-owned. Our multidisciplinary team of nationally and internationally recognized researchers and planners continue to maintain recognition among federal, state, and municipal agencies and institutions in this country for expertise in providing a wide range of resource planning and management services. Over the past 25 years our firm has focused its efforts in two primary arenas:

- (1) Performing “cutting edge” research for federal and state agencies on a wide range of topics including public involvement, flood planning and management, federal infrastructure planning, risk planning, environmental valuation, recreation planning, noise management, and water demand forecasting
- (2) Developing innovative methods and practical solutions regarding water resources planning and management for water utilities and other water agencies

PMCL not only has great depth of knowledge and experience in these subject areas, but also has the necessary technical skills, such as survey research, economic analysis, database management, and statistical analysis techniques, to assure the validity of study results. The key to PMCL’s continued success has been our aggressive approach to problem solving by utilizing state-of-the-art analyses and multidisciplinary approaches and by providing effective solutions that meet the needs of our clients. Hundreds of PMCL’s past and present clients, many of which have been repeat customers, will testify to the quality that PMCL provides.

PMCL has completed successful projects for a myriad of agencies throughout the United States, including:

- U.S. Army Corps of Engineers’ Institute for Water Resources
- U.S. Army Corp of Engineers district offices
- U.S. Department of the Interior
- U.S. Geological Survey
- U.S. Army, Air Force, Navy, and Marine Corps
- Indianapolis Water Company
- Phoenix Water Services Department
- Springfield (IL) City Water, Light and Power
- Southern Nevada Water Authority
- Lee County (FL) Regional Water Supply Authority
- California Urban Water Agencies
- Massachusetts Water Resources Authority
- Southwest Florida Water Management District

CORPORATE OVERVIEW

- Eugene (OR) Water and Electric Board
- Metropolitan Water District of Southern California
- San Diego County Water Authority
- American Water Works Association
- Orange Water and Sewer Authority (NC)

This list represents only a few of the agencies for which we are proud to have served. Our previous clients will reflect our belief—that PMCL is proud of the high degree and professional level of work we perform.

PMCL's motto is ***Bringing it Together....Making it Work***. PMCL ***Brings it Together*** by assembling the most qualified teams for a specific project and collecting all necessary data and information relevant to the topic at hand. PMCL ***Makes it Work*** by synthesizing all data and information and developing practical approaches, solutions, and recommendations for the relevant issues. PMCL's consulting goal is to focus on efficient methods of defining working solutions to issues involving resource management.

PMCL is recognized for performing quality research and producing quality products on time and within budget. The past record of high level performance, the breadth and depth of relevant qualifications and experience, and a commitment to high-quality products, all testify to our ability to provide technical and analytical support for multifaceted projects.

The personnel of PMCL are highly qualified with years of field and research experience. Planning and Management Consultants, Ltd., is comprised of engineers, econometricians, geographers, economists, social scientists, statisticians, natural resource planners, and computer programmers with an extensive amount of research and field experience related to natural resource and environmental planning. To best meet our clients needs, our firm has developed internal programs of expertise to address a wide range of research areas. Currently, PMCL consists of six interrelated research programs:

- Integrated Water Demand and Supply Planning
- Resource Economics and Quantitative Analysis
- Environmental Planning
- Management Information and Integration
- Military Resource Planning
- Software Engineering Services

Additionally, PMCL maintains an efficient and well-trained administrative staff to complement the efforts of each research team.

PMCL has endeavored to maintain a relatively small core staff, which is supplemented with external experts with whom the firm has had long-established working relationships. These

alliances add to the confidence in PMCL's performance that is reflected in PMCL's broad client base. This organizational structure assures clients that they will receive products prepared by the highest qualified personnel at very reasonable costs and with a low competitive overhead. Moreover, it allows the firm flexibility to obtain the most appropriate and skilled personnel required for each specific project.

In summary, PMCL would like to emphasize that the firm (1) is composed of highly trained personnel from different professional disciplines, who are active both in research and in work with practical problems; (2) has a special thrust in the integrated water demand and supply planning field and is keenly sensitive to, and experienced with, the objectives and constraints of water utilities; (3) views each project uniquely and is able to tailor the study according to interdisciplinary needs and the social/political characteristics of a particular area; (4) has the necessary human resources in addition to the hardware and software resources to complete data collection, data analysis, graphic design and reproduction, and other material requirements; and (5) has a working knowledge and considerable experience in the variety of activities within the field of water resource planning. PMCL can work with water utilities to develop practical and effective solutions to a wide range of water resource issues.

INTEGRATED WATER DEMAND AND SUPPLY PLANNING

This profile and qualification primarily focuses on the **Integrated Water Demand and Supply Planning** program. The mission of this program is:

To provide optimal solutions for meeting water supply needs through the use of integrated water demand and supply planning and management approaches

In 1976, PMCL was built upon the belief that the traditional water supply planning activities needed to be broadened to take into consideration issues related to water demand. PMCL furthered this belief by developing state-of-the-art approaches and procedures for water demand forecasting, water use studies, water conservation planning and evaluation, and drought planning. PMCL was one of the initial advocates in the water industry for developing optimal combinations of water supply and water demand management alternatives, through an integrated planning process. Today, the Integrated Water Demand and Supply Planning program at PMCL encompasses a quarter century of experience in water resource planning and management. We recognize the many complex challenges facing water utilities in today's financial, environmental, economic, and political environment. Therefore, we provide practical and innovative planning and management strategies to help our clients balance water demands and water supplies.

The **Integrated Water Demand and Supply Planning** program at PMCL offers a comprehensive range of services for water agencies. These services are highlighted below. Expanded descriptions of services may be found in the *Project Experience* section.

INTEGRATED RESOURCES PLANNING

- Integrating Water Supply and Water Demand Management Alternatives
- Benefit-Cost Analysis
- Long-term and Short-term Water Management Plans

WATER USE FORECASTING

- Statistical Analyses of Historical Utility Water Use Patterns
- Customer Sector Water Use Forecasts
- Analysis of Annual, Seasonal, and Peak Water Demands
- Water Use Forecasts with and without Conservation Program Savings
- Analysis of Socioeconomic, Price, and Weather Influences on Water Use Forecasts
- *IWR-MAIN Water Demand Management Suite*[®] for Urban Areas
- Site-Specific Water Use Models and Spreadsheet Forecasting Tools
- Statistical Confidence Intervals for Water Use Forecasts
- *Installation Water Resources Analysis and Planning System (IWRAPS)*[®] Software

WATER DEMAND MANAGEMENT (CONSERVATION) PROGRAM PLANNING

- Systematic Approaches to Program Planning
- Water Conservation Baseline Studies
- Development of Conservation Goals
- Consumer Adoption of Water Conservation
- Estimation of Potential Conservation Program Savings
- Cost-Benefit Analyses of Conservation Program Alternatives
- Development of Conservation Master Plans

WATER DEMAND MANAGEMENT (CONSERVATION) PROGRAM EVALUATION

- Process EvaluationsBDetermining the Success of Program Implementation Procedures
- Impact EvaluationsBDetermining Water Savings from Implemented Programs, such as:
 - Plumbing Retrofit Programs
 - Landscape Programs
 - Ultra-low-flush Toilet Replacement Programs
 - Drought Restrictions/Rationing
- Program Evaluations Designed to Meet Desired Objectives
- Water Use Monitoring Programs

SPECIALIZED WATER USE STUDIES

- Seasonal/Nonseasonal and Indoor/Outdoor Water Use
- Commercial/Industrial/Institutional Water Use
- Residential Water Use
- Irrigation Water Use
- Water Use by End Use
- Relationships between Water Use and Socioeconomic, Price, and Weather Conditions

DROUGHT CONTINGENCY PLANNING

- Consumer Response to Drought
- Lessons Learned from Previous Droughts
- Optimal Drought Management Plans
- Drought Management Optimization Procedures
- Water Shortage Economic Impacts

PUBLIC UTILITY PRICING

- Cost Allocation
- Revenue Forecasting

- Analysis of Customer Equity and Fairness Issues
- Estimation of Customer Classes
- Marginal Cost Pricing
- Average Cost Pricing
- Peak-Demand Rate Design and Analysis
- Inclining Block Rate Design and Analysis
- Rate Impact Analysis

SAMPLING AND SURVEY RESEARCH METHODS

- Sample Design
- Determination of Sample Sizes
- Specialized Questionnaire Development
- Telephone, Mail, and Personal Interview/Field Survey Formats
- Contingent Valuation Methods

TRAINING AND SPECIALIZED WORKSHOPS

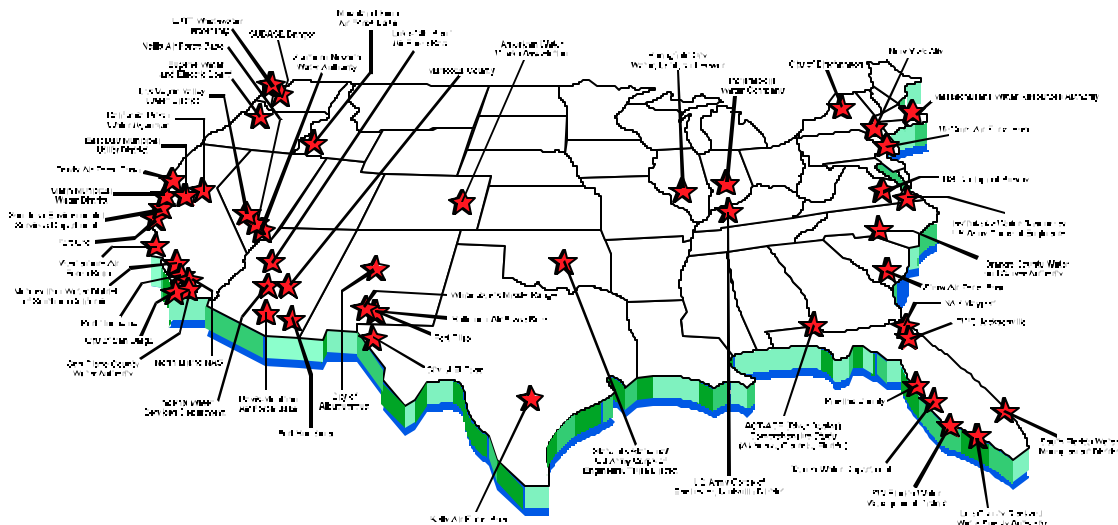
- Specialized Training offered in:
 - *IWR-MAIN Water Demand Management Suite8* Software
 - *Installation Water Resources Analysis and Planning System (IWRAPS8)* Software
 - IWR-PLAN Decision Support System
 - QUADRANT, Operations and Maintenance Management Tool
 - Planning and Evaluating Urban Water Conservation Programs
- Facilitated Workshops
- Conflict Management
- Public Involvement Programs

SCOPE OF SERVICES

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99

1. *Journal of the American Medical Association*, 1997; 278: 1039-1044.

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INTEGRATED RESOURCE PLANNING

EVALUATING URBAN WATER CONSERVATION PROGRAMS: A PROCEDURES MANUAL

Recognized as a leader in the application of innovative water-savings measurement techniques, PMCL was retained by the California Urban Water Agencies (representing the eleven largest water purveyors in California) to prepare a manual for evaluating urban water conservation programs. This study, entitled *Evaluating Urban Water Conservation Programs: A Procedures Manual* (1993), was the first guidance on experimental design issues for water conservation program planning. The *Manual* provides detailed procedures for conducting empirical evaluations of implemented conservation programs. Within the manual, the recommended analytical steps of program evaluation are: (1) design a plan for evaluating the *implementation process* of a conservation program; (2) design an evaluation plan for determining the *impacts* of a water conservation program (i.e., the water savings); and (3) develop a long-term program for *monitoring* water use and conservation. Furthermore, the manual provides guidance on research designs, sampling plans, survey techniques, and water-savings estimation methods. The *Manual* was subsequently published by the American Water Works Association and has fast become a standard reference for planning and evaluating urban water conservation programs.

The success of the *Procedures Manual* led to a series of two-day training sessions. Under the sponsorship of the Metropolitan Water District of Southern California, this training was designed for the water conservation planner and was accompanied by a comprehensive *Workbook*. In the training course, adequate attention was given to theoretical issues that enhance student's understanding of the practical water-planning tools presented. Using the *Procedures Manual* and the *Workbook*, PMCL has been involved in number of workshops around the country providing instruction on water conservation planning and evaluation methods. These include workshops in California (3 workshops), Colorado, Nevada, and New Mexico.

REGIONAL URBAN WATER MANAGEMENT PLAN FOR THE METROPOLITAN WATER DISTRICT OF SOUTHERN

PMCL was commissioned by the *Metropolitan Water District of Southern California* to prepare the *Regional Urban Water Management Plan* to meet the requirements of the Urban Water Management Planning Act. The Plan incorporates municipal, industrial, and agricultural water demand projections for the Metropolitan Water District (MWD) for a 30 year planning horizon. In close coordination with Metropolitan staff from both the planning and resources and the operations divisions, PMCL documented all aspects of water demand and water supply conditions and management strategies. As part of the project, the PMCL team (MARRS and PMCL): (1) researched, compiled, and presented an annotated report outline and reference

materials for member agency workshops on how to prepare an Urban Water Management Plan; (2) provided a summary of Metropolitan's Urban Water Management Plan in relation to how Metropolitan would manage regional water demands; (3) conducted background research and provided statistics on the affect of water conservation practices on water demand; and (4) organized the report to provide a quick reference guide to understanding of the Urban Water Management Planning Act.

DEVELOPMENT OF WATER DEMAND FORECASTS FOR THE OWASA COMPREHENSIVE WATER/SEWER MASTER PLAN

PMCL, as subcontractor to CH2M-Hill, developed the water demand forecasts as one component of the Comprehensive Water and Sewer Master Plan for the Orange Water and Sewer Authority (OWASA). OWASA provides water and sewer service to the municipalities of Carrboro and Chapel Hill, North Carolina, as well as the campus and hospital facilities of the University of North Carolina – Chapel Hill. Water use characteristics were evaluated from monthly data for the single-family, multifamily, commercial, irrigation-only and University sectors. The single-family, multifamily and University sectors each averaged more than 25 percent of total water consumed. Historical and projected service area demographics (housing, employment, and University facility gross square footage) were prepared by CH2M-Hill. Log-linear regression models were developed with monthly indicators and weather departure variables for each sector and subsector. Water demand forecasts were estimated using the Forecast Manager of the IWR-MAIN Water Demand Management Suite for all combinations of expected, high, and low growth with normal, cool-wet, and hot-dry weather conditions.

The end-use model of the Conservation Manager of the IWR-MAIN Water Demand Management Suite was used to estimate the impact of conservation on future water demand. To the extent possible, conservation assumptions were based on previous end-use studies and discussions with OWASA and UNC staff. There were no surveys conducted to collect primary end-use data from OWASA water users. A baseline forecast was calibrated to the expected growth/normal weather forecast scenario. Seven potential water demand management programs, plus two emergency restriction programs were stipulated with estimated implementation conditions and assumed program costs. The impact of these programs, as well as the impact of passive conservation, were estimated using the IWR-MAIN Conservation Manager software.

Passive conservation savings were estimated to reduce the estimated 2050 total raw water demand by 18 percent. The baseline characteristics of the OWASA service area indicate that most of the water demand is for indoor use, with about 17 percent of 1995 annual average use for toilet usage. Thus, the impact of passive conservation is significant over the 50-year planning horizon. Active conservation provided an estimated additional 4 percent savings in 2010 and 1 percent savings in 2050. The benefit-cost analysis compared the estimated program implementation costs with the savings from deferral of reservoir, WTP and WWTP expansion options in future years. Recommendations were made for improving the understanding of the

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seasonal water use (especially irrigation use), information about the characteristics of water use (i.e., the distribution of end uses within the residential and University sectors), and refining the conservation program implementation costs. Given the uncertainty of the conservation parameters, future weather, and future growth, the expected growth/ normal weather baseline forecast was selected for use in subsequent elements of the overall OWASA Master Plan.

WATER USE FORECASTS AND CONSERVATION EVALUATION FOR THE EUGENE WATER AND ELECTRIC BOARD

As part of their integrated resource planning process, the Eugene Water and Electric Board (EWEB) Water Resource Management Plan called for a reliable, accepted, and flexible methodology of forecasting water demands and evaluating potential impacts of water conservation programs. In recent years, peak demand has approached the system capacity, thus one immediate concern of EWEB was identifying major contributors to peak demand and developing programs to reduce this demand. Water demand forecasts and assessments of water conservation savings were also needed as components of EWEB integrated resource management plan that considers both supply and demand alternatives. A long-term concern of EWEB was to demonstrate the future needs for water in order to secure water rights for the future.

This project included the application of the IWR-MAIN Version 6.0[®] Water Demand Analysis Software to the EWEB service area. The application included the development of a water demand forecast, the evaluation of savings from both current and planned conservation efforts, a benefit-cost analysis of demand management alternatives, and training of EWEB staff in the use and operation of the IWR-MAIN software. A major component of the project was the utilization of the IWR-MAIN conservation end use models to reflect local water use behaviors and to closely estimate impacts of existing and potential water conservation programs. Successful completion of this project prepared EWEB personnel to update and revise the IWR-MAIN forecasts and estimates of conservation savings as conditions change within the service area and to reevaluate benefit-cost ratios as new information becomes available.

WATER USE FORECASTING

An integral part of any water management plan is the development of a reliable water use forecast. PMCL has years of experience in working with water utilities and agencies in preparing analyses of water use patterns, developing water use forecasts by customer sector, and evaluating the influences of socioeconomic factors, price and weather upon water demands.

IWR-MAIN WATER DEMAND MANAGEMENT SUITE

PMCL was pleased to announce, in February 1999, the release of the newest version of our IWR-MAIN water use forecasting and conservation evaluation software tool. Since the early 1980s (originally under the sponsorship of the Institute for Water Resources of the U.S. Army Corps of Engineers), PMCL has been the primary developer, advocate and applicant of IWR-MAIN. Through numerous studies, PMCL has developed an extensive knowledge base about the patterns and determinants of residential, commercial, and industrial water use. The recently updated IWR-MAIN Water Demand Management Suite[®] is the culmination of a quarter century of research and experience to advance the tools available for those who plan for and manage water resources. Specifically, IWR-MAIN has been designed for:

- (1) Projecting municipal and industrial water demands
- (2) Analyzing the potential water savings from water demand management (water conservation) programs and incorporating these savings into projections of water demands
- (3) Analyzing the potential monetary benefits and costs of water conservation alternatives

The IWR-MAIN Water Demand Management Suite can facilitate decision making in the following areas:

- Water demand forecasting
- Drought planning
- Master planning
- Rate analysis
- Watershed planning
- Capital improvement planning
- Integrated resource planning
- Conservation planning and evaluation

This version of IWR-MAIN is designed for Windows98, Windows95, and Windows NT platforms. Compared to previous versions of IWR-MAIN, we have added several new and enhanced features.

The IWR-MAIN Water Demand Management Suite was recently used in developing sector level water demand and estimates of conservation savings for the Orange Water and Sewer Authority (NC). Using previous versions of IWR-MAIN, PMCL has conducted water use forecasts and conservation analyses for a wide range of agencies including the Metropolitan Water District of Southern California, the Phoenix Water Service Area, the Eugene (OR) Water and Electric Board, the Southern Nevada Water Authority, the Springfield (IL) Water, Light, and Power, and Lee County (FL) Regional Water Supply Authority, and the Massachusetts Water

PROJECT EXPERIENCE

Resources Authority. PMCL has prepared water demand forecasts and conservation analyses for hundreds of study areas and our experience in this field is second-to-none in the water industry. Our study areas have ranged from small water utilities to large regional wholesale water providers. The geographic definitions of the study areas have included cities, counties, water service areas, watersheds, and river basins.

PMCL has conducted training courses on water demand forecasting and water conservation planning using IWR-MAIN around the country including courses in St. Louis, Los Angeles, Las Vegas, Fort Lauderdale, Puerto Rico, Toronto, and Hawaii.

DEVELOPMENT AND VERIFICATION OF SECTORAL WATER DEMAND FORECASTING MODELS FOR THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

PMCL updated the econometric water use models used by Metropolitan Water District to forecast municipal and industrial water demands. Using utility-level billing data from over 40 retail water agencies, these models estimated water demands for the single-family, multifamily, and nonresidential sectors. The econometric water use measurement techniques estimated water use elasticities with respect to marginal price, persons per household, median household income, housing density, departures from normal weather conditions, and productivity-adjusted employment among eight major industrial sectors. The models also specified other variables to quantify the effects of voluntary conservation programs and the protracted drought that occurred in the late 1980s and early 1990s. PMCL automated the predictive water demand relationships within a multi-layered Excel[®] spreadsheet program (MWDMOD97).

DEVELOPMENT OF A LONG-TERM WATER USE FORECAST FOR THE SDCWA SERVICE AREA

For the San Diego County Water Authority service area, PMCL had developed water demand forecasting models for single-family, multifamily, and nonresidential sectors using utility-level billing data from 20 retail water agencies. PMCL also formulated an econometric water use forecasting model to estimate regional water use elasticities with respect to the marginal price, persons per household, median household income, housing density, departures from normal weather conditions, and productivity-adjusted employment among eight major industries. The models had also specified other variables to quantify the effects of voluntary conservation programs and the protracted drought that occurred in the late 1980s and early 1990s. For this project, PMCL developed a customized spreadsheet-forecasting tool to automate the baseline water demand process, and to facilitate sensitivity analysis with respect to an array of demographic assumptions in the models. The conservation component of the *IWR-MAIN Water Demand Analysis Software* Version 6.1 was used to forecast the effects of future, planned, conservation programs on water demand.

ACT-ACF COMPREHENSIVE STUDY: MUNICIPAL AND INDUSTRIAL WATER USE FORECASTS

This project provided the *municipal and industrial (M&I)* water use forecasts for the *Alabama-Coosa-Tallapoosa and Apalachicola-Chattahoochee-Flint River Basins Comprehensive Study*. Municipal and industrial demands include all water uses, both publicly-supplied and self-supplied, described as residential, commercial, governmental/institutional, industrial/manufacturing, and *other* demands such as unaccounted (e.g., distribution system losses) water use. The planning period for the study encompassed a 60-year horizon. The river basins of the ACT-ACF include 33 counties in Alabama, 6 counties in Florida, and 62 counties in Georgia. Three forecast scenarios were established in order to evaluate alternatives for the management and utilization of water for municipal and industrial purposes within the ACT-ACF study area. The three scenarios looked at the M&I demand for water using 1990 water use conditions (as a baseline) and two levels of water conservation activities. The three scenarios are defined as:

Scenario 1: Water use projections that considered 1990 water use patterns but not additional water conservation activities (beyond that measured in the water use modeling data) and were driven primarily by projected changes in employment and housing characteristics in the study area.

Scenario 2: Water use projections which considered Scenario 1 demographic projections plus the *passive* increases in water use efficiency since 1990 resulting from implemented plumbing codes, the natural replacement of water fixtures, and known increases in residential water and wastewater rates since 1990.

Scenario 3: Water use projections which included the water efficiency increases of Scenario 2, a study area-wide implementation of selected *active* demand management programs which included a toilet rebate program, a residential indoor/outdoor audit, and a commercial/industrial indoor/outdoor audit, also a summer surcharge for residential customers, and an area-wide increase in residential water and wastewater rates (commensurate with known increases implemented in Scenario 2).

The residential water demand models for this study were developed using water use data collected from water utilities within the study area, socioeconomic data collected from the U.S. Census, and National Weather Service data. The nonresidential water use model was developed based on nonresidential water use data collected by water utilities, an in-house database of nonresidential water use by standard industrial classification code, and secondary sources. A productivity variable was also incorporated into the nonresidential model. These models were then used to produce an estimate of per county water demand using the *IWR-MAIN Water Demand Analysis Software, Version 6.1*®.

WATER DEMAND MANAGEMENT (CONSERVATION) PROGRAM PLANNING

PMCL has developed many concepts, procedures, and systematic approaches to the planning of water conservation programs. We have worked with water utilities in conducting water conservation baseline studies, developing conservation goals, estimating potential conservation program savings, and developing conservation master plans.

EAST BAY MUNICIPAL UTILITY DISTRICT (EBMUD) WATER CONSERVATION BASELINE STUDY

The *East Bay Municipal Utility District Water Conservation Baseline Study* was conducted to gain knowledge about baseline conditions of the EBMUD service area, with respect to water-using hardware, water-using behaviors, and conservation attitudes. The goal was to provide the EBMUD water conservation planners with information to design the most cost-effective conservation programs and to provide feedback regarding ongoing conservation program efforts. The scope of the study was to determine water use characteristics of seven customer groups: single-family, multifamily, hotels/motels, restaurants, office buildings, schools, and hospitals. PMCL developed a sampling approach based on EBMUD customer information to provide a representative sample in each customer group. For each of the seven customer groups, PMCL designed a sampling plan that was both geographically representative and representative of water use patterns within each customer group. *Site surveys* were conducted to record the presence of and parameters for all indoor and outdoor water uses for the seven customer groups. In addition, a residential *telephone survey* was conducted to determine the extent of water conservation taking place as well as the household's willingness and motivation to conserve water.

Statistical analyses were performed on the data collected from each of the seven customer groups to derive such descriptive statistics as frequency distributions and measures of central tendency. Tests of statistical differences were performed on the data collected from the *telephone survey*. Either a chi-square or a *t-test* was performed to determine if there were significant differences in the water conservation attitudes and activities of respondents between east and west residency, multifamily and single-family households, high and low income, and between renter and owners of households. These same statistical analyses were performed on the data collected from the *single-family site survey*. The tests were performed to determine if there were significant differences in the presence of and parameters for particular end uses between high and low income survey participants and east and west residents.

As part of the *Baseline Study*, PMCL provided recommendations for an ongoing monitoring and evaluation plan for the EBMUD water conservation program. The recommended

plan included three primary components: (1) water use monitoring program, (2) water efficiency monitoring program, and (3) special studies and periodic surveys.

MARIN MUNICIPAL WATER DISTRICT WATER CONSERVATION BASELINE STUDY

The Marin Municipal Water District (MMWD) sought to obtain detailed knowledge about how customers use water in their service area. PMCL developed a survey and sampling approach to meet the objectives of the MMWD Water Conservation Baseline Study. All water use sectors in the MMWD service area were targeted with the survey and sampling approach. The Demand Management Company (DMC) implemented the survey questionnaires. PMCL was responsible for analyzing the data obtained during the survey implementation phase.

Six surveys were designed and implemented for the Water Conservation Baseline Study; these include: (1) residential telephone survey, (2) single-family site survey, (3) multifamily site survey, (4) nonresidential telephone survey, (5) nonresidential site survey, (6) irrigation site survey. The telephone surveys were designed to measure customer characteristics, the existence and use of water-using appliances and fixtures, landscape watering characteristics, and other conservation attitudes and behaviors. The site surveys were specifically designed to conduct counts of water-using appliances and fixtures, to measure flow rates of water-using appliances and fixtures, and to assess landscape and irrigation characteristics. Given the design of the survey instruments, the major objectives of the data analysis were to (1) characterize the purposes of water use, (2) characterize water-using fixtures and appliances, (3) identify the existence of plumbing retrofit devices, and (4) characterize water conservation attitudes and behaviors.

CITY OF SAN JOSE WATER USE AND CONSERVATION BASELINE STUDY

PMCL conducted a baseline water use and conservation study for the City of San Jose. The study objectives for the City of San Jose were very similar to the previously conducted studies for EBMUD and Marin MWD; that is, to determine the baseline water use and conservation characteristics of their service area so that they can more cost-effectively design and monitor conservation programs. PMCL designed survey forms for single-family and multifamily water users. There were two primary data collection activities to meet the study objectives. The first was to conduct *site surveys* of selected customer groups. This data collection activity required targeting specific customer groups and selecting representative samples. The second data collection activity included the *data logging* of a subsample of customers who participated in the site surveys. The data loggers are used to measure nearly instantaneous pulses of water use, and the resultant measurements generate a flow trace precise enough to identify patterns and quantities of water used for individual end-uses. The data logging measurements were translated into quantities of water used for component end uses such as toilets, showers, baths, dishwashers, irrigation, etc. Together with customer billing records,

these data were used to estimate statistical water demand relationships that can be used to assess water conservation potential.

WATER DEMAND MANAGEMENT (CONSERVATION) PROGRAM EVALUATION

PMCL recognizes that program evaluation is an essential component of the water conservation process. Conservation program evaluation and measurement techniques implemented by PMCL include analyzing customer adoption and participation in water conservation programs, determining water savings from implemented programs, and establishing on-going water use monitoring programs.

PLUMBING RETROFIT AS A BEST MANAGEMENT PRACTICE: CHOOSING A POLICY ESTIMATE OF WATER SAVINGS

PMCL provided an analysis of plumbing retrofit programs for the Metropolitan Water District of Southern California. Interior plumbing retrofit programs have been shown to produce significant water conservation savings through the distribution of water conservation kits that contain low-flow showerheads or flow restrictors and toilet tank dams or water displacement bags. In accordance with the urban water conservation best management practices (BMPs), many more water agencies are expected to design and implement similar plumbing retrofit programs in the coming years. Many studies have been undertaken to measure the actual water savings from indoor plumbing retrofit programs, with no clear consensus on the level of water savings one can expect. Efficient planning requires one to predict, or *map*, the level of water conservation that can be achieved from plumbing retrofit. As part of this project, a retrofit mapping function has been developed from the empirical review of 27 documented retrofit evaluations that were performed across the United States and in Canada.

As applied to general Metropolitan service area single-family household characteristics, the mapping function suggests a value of 15.8 gallons per household per day (gphd) as the estimated average household water savings from plumbing retrofit. This value may be used for general policy decisions regarding certain planning aspects of the BMP process and Metropolitan's Water Conservation Credits Program.

The estimated mapping function provides a geographically flexible planning tool. The mapping function can be used to predict average household water savings from retrofit programs in *any* Metropolitan agency or subagency, based on specific and accessible agency characteristics on household size and average water use.

WATER CONSERVATION PROGRAM EVALUATION FOR THE CITY OF ALBUQUERQUE

For the City of Albuquerque, PMCL worked with CH2MHILL on a water conservation program evaluation. PMCL's responsibilities included elements related to both process and impact evaluation. First, PMCL reviewed and critiqued evaluation methods currently used by City staff. Next, PMCL prepared a comprehensive program evaluation methodology that can be used to estimate water savings from implemented programs. In addition, PMCL supported the development of an ICI water conservation program for the city, providing techniques to monitor and track the participation, coverage, and savings from the program. PMCL provided analysis and research of a potential cooling water ordinance. Finally, PMCL integrated, ranked, and recommended program alternatives to meet the City's desired water conservation objectives.

ANALYSIS OF WATER-SAVINGS AND COST-EFFECTIVENESS OF REDUCED WASTEWATER FLOWS

PMCL is currently conducting a water savings and cost-effectiveness evaluation of eight pilot water conservation programs implemented across residential and nonresidential sectors for the LOTT Wastewater Partnership (Olympia, Washington). This study involves pre- and post-program surveys and a statistical analysis of water savings. The cost of achieving these water savings will be compared to the cost of adding additional wastewater treatment capacity to gauge the cost-effectiveness of full implementation of the individual programs. PMCL will also provide LOTT with guidance on how to monitor conservation program effectiveness over time.

SPECIALIZED WATER USE STUDIES

PMCL has broad experience in conducting specialized water use studies for our client's that are designed to address their unique water resource planning needs.

AWWARF RESIDENTIAL END USES OF WATER STUDY (1996-98) & COMMERCIAL AND INSTITUTIONAL END USES OF WATER STUDY (1997-99)

These studies were being conducted in collaboration with Aquacraft, Inc. and John Olaf Nelson--Water Resources Management. The primary goal of these studies was to measure how water is used in the residential, commercial, and institutional settings and to evaluate the penetration and effectiveness of existing conservation measures. The residential study was an ongoing, multiyear tailored collaborative study with 12 cities across North America. At each of the 12 sites, PMCL developed sampling procedures to target select water utility customers for a mail survey and then developed sampling procedures to target select mail survey respondents for

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the installation of flowmeter loggers. Survey information was collected on more than 5,000 residences, and billing data were collected from 12,000 residences. The Project Team collected precise end use data from 100 single-family residences in each city. The Aquacraft flow trace analysis system was used to collect the data and disaggregate it into component end uses such as toilets, showers, clothes washers, etc. Participating utilities include: San Diego, the Metropolitan Water District of Southern California, Phoenix, Scottsdale, Tempe, Seattle, Tampa, Eugene, Denver, Boulder, and Waterloo/Cambridge Ontario. Results of this study were published by the AWWA Research Foundation and the American Water Works Association (AWWA).

The commercial and institutional (C&I) phase of the AWWARF end use study was a tailored collaborative study with five cities in the United States. The study increased the information base on CI classes of customers and their specific end uses of water in order to improve the ability of water planners to plan CI efficiency programs and to evaluate the potential savings and cost effectiveness of such programs. Written surveys, site surveys, data logging, and micro metering was utilized to characterize the end uses of water in commercial and institutional settings across the country. Results of this study are pending publication (in 2000) by the AWWA Research Foundation and the American Water Works Association.

CITY OF PHOENIX WATER USE MONITORING PROGRAM: A MULTIOBJECTIVE STUDY OF SINGLE-FAMILY HOUSEHOLD WATER USE

The first phase of the water use and conservation monitoring program was an analysis of water-use behaviors among single-family residential customers. Data from a telephone survey of 494 single-family households conducted in November 1989 included information on water customer attitudes, conservation behaviors, awareness of conservation media campaigns, lawn characteristics and watering methods, and socioeconomic characteristics of each household. A field survey of each household in the sample conducted in the summer of 1990 provided information on landscape characteristics, swimming pools, and the size of lots, houses, and landscapable areas. In September 1990, the water meters for each of the customers in the sample were replaced and tested for accuracy. Water consumption records were obtained for each of the sample accounts for the period from April 1989 through December 1990. Data from all these sources were merged into one database for analysis. Water-use related characteristics of the sampled households now serves as a baseline for the monitoring of water-use behaviors and attitudes over time.

The second phase of the monitoring program concerned an analysis of the impact of the water conservation programs that had been promoted by the City of Phoenix Water Services Department (PWSD). Different statistical methods were used to identify single-family water use trends that are important to PWSD's water conservation and planning process. Based on data that included weather conditions, monthly billing records, and socioeconomic information, seasonal forecast models were constructed. The ordinary least squares (OLS) estimator was dropped in favor of a random effects (RE) formulation of estimated generalized least squares

(EGLS) that accounted for heterogeneity among sample households. In order to rid the price variable of its endogenous relationship with water use, a two-stage-least-squares procedure for estimation was introduced. Next, a conditional demand analysis was employed to estimate average seasonal levels of indoor and outdoor water use in the single-family sector. Also, with the use of the model, irrigation demands were isolated and deficit/surplus irrigation was assessed. In particular, the characteristics of over-irrigators were identified. Finally, the impact on water use attributable to the change in PWSD's water rate structure that occurred in June 1990 was analyzed. Demand impacts were estimated using a 39-variable structural model of single-family household water use. Within this study, the impact of a voluntary water conservation program was distinguished from the impact of the change in the water rate structure. The change in water rate structure was shown to influence water use through increases in marginal price, with voluntary participation as one component of the response to marginal price.

DROUGHT CONTINGENCY PLANNING

PMCL has demonstrated in past research that explicit consideration of water shortages and means of dealing with them may result in considerable savings in water supply investment. PMCL has created a technique that allows planners to formulate optimal least-cost drought emergency plans.

WATER SHORTAGE ECONOMIC IMPACT MODEL

This report estimated the potential economic losses due to drought in the South Florida Water Management District. Inferences were made concerning the types and degree of economic impact associated with water use restrictions detailed in the District's Water Shortage Plan. Public response to water shortage was found to involve both technical and behavioral change. The costs associated with these responses were quantified by careful analysis of the literature and conservation alternatives. Various loss estimation methods were reviewed and found to generate different economic loss estimates for the residential sectors. The potential economic loss estimates for the SFWMD were developed by integrating contingent valuation (CV) estimates of willingness to pay to avoid water shortage, with the direct cost of implementing technical conservation adjustments. A contingent valuation framework was developed for a proposed District-wide application. A case study was examined to demonstrate the applicability of the CV procedure to the District, as well as to show the CV method's usefulness as an operative decision tool. Economic losses to the commercial and industrial sectors were described by examining the direct capital costs of implementing water conservation measures. Throughout the analysis it was assumed that producers undertake least cost adjustments in order to maintain production in the face of water shortage. Documented survey responses of business adjustment to water shortage were reviewed and judged to be consistent with this least cost hypothesis.

THE NATIONAL STUDY OF WATER MANAGEMENT DURING DROUGHT: A RESEARCH ASSESSMENT

This project was undertaken by the Corps of Engineers as a step towards evaluating the nation's preparedness for drought. The study examined the literature and previous research conducted on drought, summarized five state drought plans, reviewed drought preparedness at the local, state, and national levels, examined the legal environment that surrounds drought planning, and discussed the economic impact of severe water shortage. The construction of optimal drought plans was also covered in detail. The report set forth a research agenda for further inquiry into drought, identifying those areas of study that would be most profitable. This research assessment was a contribution to the National Study of Water Management During Drought undertaken by the U.S. Army Corps of Engineers.

LESSONS LEARNED FROM THE CALIFORNIA DROUGHT 1987-1992

This project was undertaken by the United States Army Corps of Engineers, Institute for Water Resources (IWR) as part of a comprehensive study undertaken in response to recommendations of the National Drought Study. The purpose of this report was to identify, categorize, explain, and verify the important lessons learned during the multiyear California drought of 1987-92. The lessons of the drought were formed using a carefully designed research approach consisting of personal interviews with members of the California water community and other key individuals in the state as well as a thorough review of documents and reports pertaining to the drought. The resulting lessons pertain to various levels of drought management and are directed to federal, state, and local levels of government, water institutions, and water users (urban, agricultural, environmental, and others) for improving the management of water resources during future droughts in California and other states throughout the nation.

DEVELOPMENT AND PROTOTYPICAL APPLICATION OF WATER SUPPLY OPTIMIZATION PROCEDURES

The purpose of this two-phase research project was to develop and apply a model for the optimization of drought planning procedures. The formulation of various strategies for addressing a water shortage was central to the model. The conceptual basis for the model was derived from a careful review of the literature on drought planning. The model, known as drought optimization planning procedures, or DROPS, is the central focus of the report. Its purpose is to provide water managers with guidance in choosing the appropriate measures when planning for and/or coping with a drought. These measures include: additions to storage

capacity, water conservation measures, reduction of water use or water losses, and use of emergency water supplies.

Using the cities of Phoenix, Arizona and Springfield, Illinois, this project illustrated the validity of a comprehensive method for determining optimal deficit management strategies for municipal and industrial water supplies in a real planning situation. The method comprises several concepts, procedures, and measurement techniques that are indispensable in planning for water shortages and considers both long-run capacity investment strategies as well as short-term deficit management alternatives. These include: public information procedures, shortages assessment methods, cost of construction and operation-maintenance for emergency supplies; models for forecasting water consumption, potential demand and loss reduction measures, methods for the determination of monetary losses, and mathematical optimization techniques for management measures which minimize the total cost of shortage mitigation.

PUBLIC UTILITY PRICING

PMCL is sensitive to both quantitative and qualitative issues inherent in the analysis of the impact of price and rate structure changes on customer demand and utility revenues. PMCL has utilized a variety of economic techniques in evaluating water utility pricing policies.

MARGINAL COST PRICING RULES FOR SYSTEM NET BENEFITS, DEMAND BEHAVIOR, AND WATER UTILITY FINANCING: CONCEPTUAL UNDERPINNINGS AND CASE STUDY OF THE PHOENIX WATER AND WASTEWATER DEPARTMENT

PMCL used data from the Phoenix Water Services Department for a study case for the application of the marginal cost pricing principle. This study applied and compared three major competing marginal cost approximations (i.e., Turvey, textbook, and average marginal cost formulations). The objective of this study was to analyze the net economic benefits of substituting water prices based on each of the measures of marginal cost for a seasonal water rate structure. This evaluation required the review of alternative discount rates and assumptions concerning fixed and variable system costs, and well as the derivation of the optimal system expansion path through recursive dynamic programming. The study showed that substantial increases in economic efficiency could be realized by designing rates based on marginal cost.

ESTIMATING THE IMPACT OF A CHANGE IN RATE STRUCTURE

This study identified for the city of Phoenix the impact of a change from a normal increasing block rate design to a seasonally based increasing block rate structure. Demand

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impacts were estimated using a 39-variable structural econometric model of single-family household water use. The full specification of the model allowed for the isolation of the effects of price through the estimation of price elasticity while accounting for the many confounding factors that influence household water use. The model was estimated using a two-stage least-squares procedure and was based on a pooled, cross sectional time-series, database of 14,172 observations. The resultant model explained nearly 50 percent of the variation in the water use data. Within this study, the impact of a voluntary water conservation program was distinguished from the impact of the change in the water rate structure. The change in water rate structure was shown to influence water use through increases in marginal price, with voluntary participation as one component of the response to marginal price. The change in rate structure was estimated to have resulted in an average short-run decrease in water use of 1 to 1.6 percent.

SAMPLING AND SURVEY RESEARCH

THE CONSERVATION MEDIA CAMPAIGNS OF 1989 AND 1990: TRENDS IN CONSERVATION BEHAVIOR

The Metropolitan Water District of Southern California implemented media campaigns in 1989 and 1990 to encourage water conservation by residential customers. This report summarizes and analyzes three residential water customer surveys to measure the effectiveness of media campaigns promoting water conservation. The "Spring 89" survey was implemented prior to the 1989 media campaign. The "Fall 89" survey was conducted after the 1989 campaign and the "Fall 90" survey was completed after the 1990 media campaign. PMCL was responsible for the design of the survey questionnaire and the survey was administered by a marketing research firm. The three surveys yielded 3,000 responses from households in Southern California. The surveys addressed the following issues: (1) the customers' self-reported adoption of various water conserving practices, (2) the customer's awareness of the drought, (3) the factors which motivate or constrain conservation behavior, and (4) the impacts of the 1989 and 1990 media campaigns. Regression analysis was used to determine the effect of the 1990 media on water conservation activity. Frequencies and correlations of the survey variables are also presented.

WATER USE AND CONSERVATION DATA BASE

PMCL developed a *Water Use and Conservation Data Base* for the City of San Diego. A primary purpose of this study was to provide a means for San Diego water conservation planners to obtain information on utility customers with respect to water-using behaviors and attitudes. The two major components of the data base include: (1) water billing records for a sample of San Diego water customers and (2) survey responses from the sample of customers who completed

mail questionnaires. Sampling techniques were used to develop representative samples of customers from six customer classifications. The surveys were sent to the sample single-family customers, multifamily owners and managers, and nonresidential businesses (three different survey instruments were used). Of 4,047 mail surveys sent, responses were returned from 1,765 customers (a 44 percent response rate). The survey data measured conservation attitudes, awareness and knowledge of conservation programs, conservation and other water use behaviors, and situational characteristics of customers. The objectives of the analyses of the survey response and water billing data components included (1) identification of general water use characteristics of selected customer classes, (2) identification of the major factors that affect water use and conservation behavior, (3) determination of the market penetration of existing conservation programs, (4) identification of characteristics of conservers and nonconservers, and (5) identification of the potential for conservation program improvements.

PMCL also developed a computer program interface that allows San Diego water conservation planners to access and analyze the information contained within the data base. In addition to the survey responses and water billing records, other components of the *Water Use and Conservation Data Base* include: (1) aggregate water sales by customer classes, (2) total water deliveries to city, (3) weather-related parameters, and (4) conservation program tracking data. The *Water Use and Conservation Data Base* became the baseline measurements for the City of San Diego in their tracking and monitoring of water conservation program activities.

TRAINING AND SPECIALIZED WORKSHOPS

PMCL has been involved in a number of workshops that train participants in specialized procedures, concepts, and/or software programs. PMCL training courses typically follow a planning process or computer software package designed and developed by PMCL.

EVALUATING URBAN WATER CONSERVATION PROGRAMS: WORKBOOK

The Metropolitan Water District of Southern California recognized the value of methods and procedures presented in the *Procedures Manual* as a tool for providing guidance to Conservation Coordinators on how to plan and evaluate water conservation programs. Therefore, Metropolitan contracted with PMCL to prepare a workbook that (1) presented some of the methods and procedures in more simplified terms and (2) provided additional examples and exercises that would allow greater understanding of the methods and procedures. The resultant product was entitled *Evaluating Urban Water Conservation Programs: Workbook*. The *Workbook* addresses each one of the steps presented above through the various workshop sessions. As part of the development of the *Workbook*, PMCL designed over 100 view graphs as presentation materials. Using the *Workbook*, PMCL representatives have conducted three two-day workshops in Southern California and one-day workshop in Colorado, providing guidance

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and assistance to Conservation Coordinators in process evaluation. PMCL also participated in an AWWA-sponsored conservation training course held in Santa Fe (NM), where the primary resource material was the *Workbook*. Based upon the course evaluations and other feedback, the workshops were extremely well-received. Many beginning and advanced water conservation planners indicated that this was the exact type of guidance that they needed in their conservation program efforts.

IWR-MAIN WATER DEMAND MANAGEMENT SUITE[®]: TRAINING COURSE[®]

Planning and Management Consultants, Ltd. conducts a three day workshop on the use of the *IWR-MAIN Water Demand Analysis Software, Version 6.1[®]* (now the *IWR-MAIN Water Demand Management Suite[®]*). Typically, attendees included water resource planners from a number of federal, state, and local agencies from locations throughout the United States. The course is offered to provide water resource planners with a working knowledge of the *IWR-MAIN* software. Each participant receives the *IWR-MAIN Water Demand Management Suite[®]* and Manual, the training course materials, and a certificate of course completion.

The three day course consists of five working sessions, (1) overview of the purpose and function of the *IWR-MAIN* software and manual and the need for such tools in integrated resources planning, (2) theoretical and operational overview of the *IWR-MAIN* forecasting procedures, (3) theoretical and operational overview of the *IWR-MAIN* conservation procedures, (4) theoretical and operational overview of the benefit-cost procedures, and (5) open discussion as well as one-on-one discussions focusing on site specific applications of *IWR-MAIN*. The forecast, conservation, and benefit-cost sessions provide participants with “hands-on” computer exercises which contribute to their working knowledge of both the *IWR-MAIN* software and manual. The *IWR-MAIN Water Demand Management Suite[®] Training Course Workbook* provides a complete illustration of the training workshop.

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PROJECT EXPERIENCE

Seasonal Components of Urban Water Use in Southern California. Prepared for: The Metropolitan Water District of Southern California, Los Angeles, CA.

Commercial and Industrial Water Use in Southern California. Prepared for: The Metropolitan Water District of Southern California, Los Angeles, CA.

Water Use Model for Fixed Army Installations. Prepared for: U.S. Army Corps of Engineers, Institute for Water Resources, Fort Belvoir, VA.

Water Demand of Detached Single-Family Residences: Empirical Studies for the Metropolitan Water District of Southern California. Prepared for: The Metropolitan Water District of Southern California, Los Angeles, CA.

Analysis of Residential Landscape Irrigation in Southern California. Prepared for: Metropolitan Water District of Southern California, Los Angeles, CA.

A Survey of Air Force Base Water Resources Characteristics for Water Demand Planning. Prepared for: Headquarters Air Force Civil Engineering Support Agency, Tyndall AFB, FL.

Water Conservation Audit for Construction Battalion Center Port Hueneme California. Prepared for: Facilities Engineering Support Center, Port Hueneme CBC, CA.

Water Conservation Audit for Naval Air Station North Island California. Prepared for: Facilities Engineering Support Center, NAS North Island, CA.

Assessment of Illinois Water Quantity Law. Office of Water Resources, Illinois Department of Natural Resources, 3215 Executive Park Drive, Springfield, IL.

Drought Contingency Planning

Evaluation of Drought Management Measures for Municipal and Industrial Water Supply. Prepared for: U.S. Army Corps of Engineers, Institute for Water Resources, Fort Belvoir, VA. IWR Contract Report 83-C-3.

Prototypal Application of a Drought Management Optimization Procedure to an Urban Water Supply. Prepared for: U.S. Army Corps of Engineers, Institute for Water Resources, Fort Belvoir, VA. IWR Contract Report 83-C-4.

Optimal Drought Plans. Volume I: Prototypal Application of the "DROPS" Method. Prepared for: United States Department of the Interior, Geological Survey, Reston, VA.

PROJECT EXPERIENCE

Optimal Drought Plans. Volume II: Evaluation of Economic Losses Resulting From Water Supply Shortages. Prepared for: United States Department of the Interior, Geological Survey, Reston, VA.

Drought Management for the Phoenix Water Supply System. Prepared for: Phoenix Water and Wastewater Department, Phoenix, AZ.

Consumer Response to Drought. Prepared for: Metropolitan Water District of Southern California, Los Angeles, CA.

Water Management During Drought: A Research Assessment. Prepared for: U.S. Army Corps of Engineers, Institute for Water Resources, Fort Belvoir, VA.

Drought Contingency Plan for the Metropolitan Water District of Southern California. Prepared for: Metropolitan Water District of Southern California.

Lessons Learned from the California Drought (1987-1992). Prepared for: U.S. Army Corps of Engineers, Institute for Water Resources, Fort Belvoir, VA.

Training and Specialized Workshops

IWR-MAIN Water Demand Management Suite Software Training Course. Conducted in St. Louis, MO.

Technical Support to USGS, Memphis in Application of IWR-MAIN Water Demand Management Suite.

Training in Application of IWR-MAIN Version 6.1 for the Georgia Department of Natural Resources. Atlanta, Georgia.

IWR-MAIN Version 6.1 Water Demand Analysis Software Training Course. Conducted in St. Louis, MO.

Training in Application of IWR-MAIN Version 6.1 for the San Juan, Puerto Rico, Corps of Engineers. Prepared for: U.S. Army Corps of Engineers, Institute for Water Resources, Alexandria, V.A.

IWR-MAIN Version 6.1 Water Demand Analysis Software Training Course. Conducted in Ft. Lauderdale, Florida.

Training in Application of IWR-MAIN Version 6.1 for the North West Water Company. Toronto, Canada.

PROJECT EXPERIENCE

Water Planning and Management Issues Related to Army CONUS Installations: A Working Conference. Prepared for U.S. Army Corps of Engineers, Institute for Water Resources, Fort Belvoir, VA.

Urban Water Management Plan: An Annotated Report Outline and Reference Materials. Prepared for: The Metropolitan Water District of Southern California, Los Angeles, CA.
Decision-Making Environment and Decision Support Tools: An O&M Workshop. Prepared for: U.S. Army Corps of Engineers, Institute for Water Resources, Fort Belvoir, VA.

Water Supply and Conservation Planning with IWR-MAIN, Training Course: Participant Workbook. Prepared for: U.S. Army Corps of Engineers, Institute for Water Resources, Fort Belvoir, VA.

Manpower Management Software Review Workshop. Prepared for U.S. Army Corps of Engineers, Fort Belvoir, VA.

Valuation of Environmental Investments Research Program Workshop. Prepared for: U.S. Army Corps of Engineers, Institute for Water Resources, Fort Belvoir, VA.

Civil Works Task Force to Review and Structure FY93 Planning and Project Management Long-Term Training Program Workshop. Prepared for U.S. Army Corps of Engineers, Institute for Water Resources, Ft. Belvoir, VA.

Civil Works Task Force to Review and Structure the Planning and Project Managers Long-Term Training Program Workshop. Prepared for: U.S. Army Corps of Engineers, Institute for Water Resources, Fort Belvoir, VA.

Environmentally Sensitive Stream Modifications Workshop. Prepared for: U.S. Army Corps of Engineers, Institute for Water Resources, Fort Belvoir, VA.

Risk Analysis for Water Resources Investments: Lecture Notes for the 1993 Training Course. Prepared for: U.S. Army Corps of Engineers, Institute for Water Resources, Fort Belvoir, VA.

Training in Application of IWR-MAIN Version 6.0 for the Los Angeles Corps of Engineers. Prepared for: U.S. Army Corps of Engineers, Institute for Water Resources, Alexandria, VA.

Upper Mississippi River - Illinois Waterway System Navigation Study. Public Information Meetings. Content Analysis Report. Submitted to: St. Paul District, U.S. Army Corps of Engineers.

IWR-MAIN Version 6.1 Water Demand Analysis Software: Training Course. Conducted in St. Louis, MO.

PROJECT EXPERIENCE

Civil Works Leadership Team Performance Measurement Workshop. Prepared for: U.S. Army Corps of Engineers, Institute for Water Resources, Alexandria, VA.

Civil Works Leadership Team Performance Measurement WorkshopB Process and Results Document. Prepared for: U.S. Army Corps of Engineers, Institute for Water Resources, Alexandria, VA.

IWR-MAIN Version 6.1 Water Demand Analysis Software Training Course. Conducted in St. Louis, MO.

Identifying Small Group Techniques for Planning Environmental Projects: A General Protocol. Prepared for: U.S. Army Corps of Engineers, Institute for Water Resources, Alexandria, VA.

PROJECT EXPERIENCE

Planning & Management Consultants, Ltd. (PMCL) has established itself as a national leader in water resources research and planning through the depth of knowledge, practical experience, and dedication of its personnel. PMCL key personnel are multidisciplinary and include planners, economists, engineers, statisticians, programmers, and researchers. This multidisciplinary nature allows PMCL to tailor personnel teams to best meet individual project objectives. Furthermore, PMCL key personnel are often supplemented with expert consultants with whom we have had long-established working relationships.

Currently PMCL has 33 full-time employees. In addition to the key staff assigned to the *Integrated Water Demand and Supply Planning* Program, additional PMCL staff have and will continue to make significant contributions to the Program's projects. A brief summary of *selected* PMCL personnel who contribute to the Program follows.

In addition to the following personnel, the **Integrated Water Demand and Supply Planning** program at PMCL is supported by highly qualified research assistants, computer programmers, graphic artists, and production support staff. These individuals have advanced degrees in geography, economics, and computer science, with experience in data collection, statistical analysis, and computer operations.

PRINCIPAL INVESTIGATORS

Jack C. Kiefer

Ph.D. Resource Management Systems, Southern Illinois University - Carbondale (in process)

M.A. Economics, Southern Illinois University - Carbondale

B.A. Economics, Southern Illinois University - Carbondale

Jack C. Kiefer leads PMCL's research programs related to Resource Economics and Quantitative Analysis, Integrated Resources Planning, Military Resources Planning, and Environmental Planning. He received his masters of arts degree in economics from Southern Illinois University, specializing in development economics and monetary theory with emphasis on econometric methods. Mr. Kiefer is currently pursuing a doctoral degree in Resource Management Systems.

Mr. Keifer is an economist presently specializing in the areas of water resource economics, econometric forecasting, navigation analysis, water conservation evaluation, and drought contingency planning. Mr. Kiefer has many years of consulting experience in the water utility and Federal water sectors. He has performed numerous econometric analyses of water demand, including the development of models and water demand forecasts for the Metropolitan Water District of Southern California, the San Diego County Water Authority, and the City of Phoenix. He has also inferred the potential economic impact of various public policy decisions concerning drought and floodplain management. He has developed a working knowledge of the

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contingent valuation method of measuring the value placed on non-marketable goods, as well as the least cost method of measuring the impact of water shortage on business and industry. Mr. Kiefer has also been actively involved in analyzing the feasibility and impact of various demand side management alternatives from the utility perspective, and has studied application and feasibility issues of marginal cost pricing and strength-based wastewater effluent charges. Recently, Mr. Kiefer has developed flood depth-damage and content value functions in support of Federal flood control projects. In addition, he has developed and applied a flood control readiness indexing procedure for performance measurement and has prepared guidance on developing Corps planning documents. Mr. Kiefer has also prepared a guidance manual on various ways to forecast inland navigation demand/commodity flows within a risk and uncertainty framework. More recently, Mr. Kiefer has evaluated the economic benefits of Corps hydropower O&M investments in the Pacific Northwest and prepared a manual for forecasting waterborne traffic within a risk and uncertainty framework. Currently, Mr. Kiefer is serving as project manager for the National Dredging Needs Study for the Institute for Water Resources, coordinating and serving as a principal investigator and reviewer on numerous tasks, including long-term commodity and trade forecasts related to deep draft navigation.

Benedykt Dziegielewski

Ph.D. Geography/Environmental Engineering, Southern Illinois University - Carbondale

M.S. Sanitary Engineering, University of Wroclaw

B.S. Sanitary Engineering, University of Wroclaw

Dr. Ben Dziegielewski is a nationally recognized expert in water resources and environmental engineering. Dr. Dziegielewski is a professor in the Geography Department at Southern Illinois University at Carbondale, where he teaches hydrology and water resource management and planning. Dr. Dziegielewski specializes in integrating the disciplines of engineering, economics, and environmental science into holistic resource management analyses. Dr. Dziegielewski has expertise and extensive experience in urban water supply planning, including water demand forecasting, drought contingency planning, water quality management, and the development and evaluation of integrated demand and supply plans. He served as a principal investigator for a number of planning and evaluation projects involving public water supply systems in New York City, Phoenix, Southern California, Indianapolis, Springfield (Illinois), El Paso, and other urban areas. Dr. Dziegielewski has also developed several analytical tools for supporting integrated water resource planning. These tools include the computer algorithms for econometric water use forecasts, benefit-cost analyses of demand-side alternatives, and integrated optimization of demand and supply-side options. He has also developed a theoretical and computer algorithms for the analysis of the impact of water rates on water use and conservation. He has authored a number of publications on water demand management, water use forecasting, and drought planning. He has also presented expert witness testimony on both water demand forecasting and demand-side water management.

Eva M. Opitz

M.S. Geography/Natural Resource Planning, Southern Illinois University - Carbondale

B.S. Geography/Biology, University of Central Arkansas

Since 1984, **Ms. Eva M. Opitz** has focused work efforts toward the development and application of innovative methods for urban water supply planning and management. Ms. Opitz has conducted water resources-related research for federal, state, regional, and local agencies and has provided consulting services for water supply utilities throughout the United States. Ms. Opitz has worked on numerous projects with a special focus on integrated water resources planning, particularly the social and economic aspects of urban water supply planning and management. Ms. Opitz has served as the senior analyst or project manager on studies involving regional urban water planning, water demand analysis and modeling, water use forecasting, water conservation planning and evaluation, water pricing strategies, and drought planning and management. In these project experiences, Ms. Opitz has utilized many technical tools including survey research, economic analysis, data base management, and statistical analysis techniques. In her more than 16 years of experience, Ms. Opitz has provided urban water supply planning and management services to numerous clients including the Metropolitan Water District of Southern California, the California Urban Water Agencies, the San Diego (California) Water Utilities Department, the East Bay Municipal Utility District (Oakland, California), the Phoenix Water Services Department, the Southern Nevada Water Authority, the U.S. Army Corps of Engineers? Institute for Water Resources (and various Corps Districts), the Eugene (Oregon) Water and Electric Board, the Southwest Florida Water Management District, the Lee County (Florida) Regional Water Supply Authority, the Indianapolis Water Company, and the Massachusetts Water Resources Authority, among others. As Vice President of PMCL, Ms. Opitz strives to provide the highest quality services and products to best meet the needs of PMCL's clients.

SENIOR STAFF

William Y. Davis

M.S. Agribusiness Economics, Southern Illinois University - Carbondale

M.S. Social Work, University of Kansas

B.S. Social Work/Psychology, University of Kansas

Mr. William Y. Davis specializes in conducting water demand analyses and developing water use forecasts. His focus includes the analysis of socioeconomic data and water utility data used in identifying local water use patterns and characteristics, water demand forecasting, and evaluating the effectiveness of conservation programs. Mr. Davis was the senior analyst in developing databases, conducting statistical analyses of water use and socioeconomic data, and preparing water demand forecasts for the City of Phoenix, the City of El Paso, the Southwest

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Florida Water Management District, the City of San Diego Water Utilities Department, and most recently the Orange Water and Sewer Authority in Carrboro NC. As senior analyst, Mr. Davis completed the *Alabama-Coosa-Tallapoosa and Apalachicola-Chattahoochee-Flint (ACT-ACF) River Basins Comprehensive Study: Municipal and Industrial Water Use Forecasts* for which separate water demand forecasts were prepared for 33 counties in Alabama, 6 counties in Florida, and 62 counties in Georgia. Mr. Davis was a member of the PMCL Development Team responsible for the new IWR-MAIN Water Demand Management Suite.

Mr. Davis has also conducted numerous workshops around the U.S. in the methods and procedures for developing water use forecasts and assessing conservation effectiveness. He has provided technical assistance to water resource planners around the country, including the city of Phoenix; the Southwest Florida Water Management District; and the U.S. Army Corps of Engineers district offices in Louisville (KY), Mobile (AL), Los Angeles (CA), and Puerto Rico. Mr. Davis strives to provide each PMCL client with a thorough understanding and working knowledge of the state-of-the-art water demand analyses and procedures in a given project.

Mr. Davis developed an economic analysis of modernizing the Water Control Data System for the Corps of Engineers. He has collected field data on economic impact of flooding with and without project conditions, and developed assessments of economic benefits of project conditions.

Michael T. Beezhold

M.S. Forestry, Southern Illinois University - Carbondale

B.S. Forestry, Southern Illinois University - Carbondale

Mr. Michael T. Beezhold specializes in natural resource management and planning. While at Southern Illinois University, his major focuses of study included environmental policy and natural resources valuation, planning, and management. He has experience in the use of benefit-cost analysis, statistical analyses, and economic valuation methods and techniques. Mr. Beezhold's thesis research, using the contingent valuation method and an iterative bid approach, measured the willingness of Illinois residents to pay both a daily and an annual entrance fee as well as an increased camping fee at Illinois managed state parks. He has work experience with several federal agencies including the United States Army Corps of Engineers and the United States Forest Service. While with PMCL, Mr. Beezhold has forecasted water demands for numerous municipalities. He has also forecasted water requirements for Navy, Air Force, and Army installations throughout the United States. Addressing the potential for water conservation has been an essential component of these municipal and military studies. Recently, Mr. Beezhold has been applying his knowledge and expertise in the arena of watershed planning. He recently completed a study for the Army Corps of Engineers: Navigation Analysis Division in the development of the *Fiscal Year 1999 Planning Guidance: Shallow Draft Vessel Costs*.

RESEARCH STAFF

Edward A. Baruch

J.D. University of Arizona

B.S. Regional Development, University of Arizona

Mr. Edward Baruch brings expertise in natural water resources, including experience in the analysis of natural resources legislation and municipal water resources authorities. As an intern for the Arizona House of Representatives he assisted the Chairman of the Natural Resources and Agriculture Committee by preparing detailed summaries of bills to be heard by the committee and aided committee staff with preparing amendments to legislation. Mr. Baruch further utilized his natural resources experience working with the Arizona Department of Water Resources, where he was involved in compilation and analysis of data on use of groundwater in Southern Arizona, and conducted field investigations of possible groundwater code violations. In addition, at ADWR he assisted the public with the conveyance of groundwater rights within the Tucson Active Management Area. Mr. Baruch also holds a Juris Doctorate from the University of Arizona College of Law and has experience handling various land-use and real estate-related matters.

Mr. Baruch's work with PMCL has involved him in the analysis of various aspects of water resource issues through the U.S. Army Corps of Engineers, Navigation Analysis Division. Recently, Mr. Baruch was involved in the collection of household and business survey data for the Corps Navigation Analysis Division that will aid in the development of comprehensive flood damage estimates for use in future planning.

Akapelwa Imwiko

M.S. Agribusiness Economics, Southern Illinois University - Carbondale

B.S. Agribusiness, Delaware State University - Dover

Mr. Akapelwa Imwiko is a research analyst in the Resource Economics and Quantitative Analysis Program of PMCL. Mr. Imwiko specializes in regional economic impact analysis. His main emphasis is Input-Output modeling. He has extensive research experience estimating impacts to regional gross earnings, total value added, and employment resulting from an economic stimulus such as a change in policy, program, or the closure or introduction of a new business to a community.

Mr. Imwiko has been involved in the evaluation of residential, industrial, commercial and institutional end-use water needs for several cities on the West Coast. He conducted field surveys to collect data on end use water needs of Single Family houses in the city of San Jose. He was also the principal author in a study estimating residential water savings and cost-effectiveness of

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water conservation projects in the cities of Lacey, Olympia, and Tumwater in the state of Washington. Mr. Imwiko recently returned from a six month work assignment in Washington D.C. where he provided research support to the U.S. Army Corps of Engineers (USACE) Institute for Water Resources (IWR).

Phillip K. Letting

Ph.D. Economics, Southern Illinois University - Carbondale (in process)

M.A. Economics, Central Missouri State University

B.S. Business Administration, Central Missouri State University

Mr. Phillip Letting is a research analyst in PMCL's Integrated Water Demand and Supply Planning for Water Utilities; and Environmental Planning Program. His expertise are in economic principles of environmental planning and restoration, water demand analyses and water use forecasts. His focus includes the analysis of socioeconomic data and water utility data used in identifying local water use patterns and characteristics, water demand forecasting, and evaluating the effectiveness of conservation programs. Most recently Mr. Letting has been involved in the following research projects:

- Conducting water use surveys in San Jose and developing the database used in conducting statistical analyses of water use and socioeconomic data, and preparing a baseline study for the city of San Jose
- Testing the new IWR-MAIN for quality control and updating forecasting databases for Municipal Water District of Southern California
- Evaluating employment and income benefits from construction of Locks and Dams along the Ohio River using Input-Output modeling

Currently Mr. Letting is a doctoral candidate in the Department of Economics at Southern Illinois University at Carbondale, pursuing dissertation research on Integrating Soil and Water Conservation Practices in a System of Regional Income Accounting: The Cache River Basin of Southern Illinois. His research is in the area of ecological-economic modeling using regional income accounting and regional input/output modeling. He has been actively involved in the building of the linear programming model for this project.

Mr. Letting has also been involved in various research projects that have utilized statistical and analytical packages such as SAS, Linear Programming, and IMPLAN (Impact Analysis for Planning) programs. Other research project experiences include: ecological-economic modeling in the Cache River Basin; a potential framework for sustainable development; land use and regional economy; policy developments that affect watershed planning in the Cache River; Combining Farm Management and Ecosystem Management; and, Insights from Representative Farm Models in a Conservation Priority Watershed.

Glen Lantz

Ph.D. Sociology, Southern Illinois University - Carbondale (in process)

M.A. Sociology, University of Northern Iowa

B.A. Sociology, University of Northern Iowa

Mr. Glen L. Lantz is a research analyst with PMCL. His expertise includes commercial and institutional water end use analysis and econometric end use models. He received his Master's degree in sociology from the University of Northern Iowa. He is currently completing work on a Ph.D. in sociology at Southern Illinois University at Carbondale. While attending the University of Northern Iowa, Mr. Lantz worked as a research assistant at the Center for Social and Behavioral Research. During his tenure at the research center, he participated in a large number of research projects. These research projects consisted of mailed surveys and computer assisted telephone interviews covering a wide range of studies from substance abuse needs assessment to state park users satisfaction. As a research analyst at PMCL, Mr. Lantz has been involved with the AWWARF Commercial and Institutional Water Use study. He has assisted in the development and summary of econometric end use models of commercial and institutional water customers.

Stuart D. Norvell

M.S. Applied Economics, Clemson University

B.A. History with emphasis in Foreign Languages, University of Charleston

Mr. Stuart D. Norvell is a Research Associate with PMCL working on issues relating to the economics of maritime trade and navigation. Current projects include an assessment of national infrastructure needs of U.S. deep draft ports being prepared for the United States Army Corps of Engineers. Before joining PMCL, Mr. Norvell was a Research Associate with the Texas Institute for Applied Environmental Research (TIAER) where he specialized in socioeconomic analyses of policy issues relating to water quality and natural resources. His responsibilities included developing innovative approaches to protecting water quality in watersheds throughout Texas and Iowa. While at TIAER, Mr. Norvell completed a study entitled, *Policy Options for the Upper North Maquoketa Watershed, Iowa: A Report Prepared for the Environmental Protection Agency: Office of Planning and Policy Evaluation*. For the study, numerous policy options to reduce water quality impacts of livestock production were developed with the assistance of stakeholder groups. Mr. Norvell also completed a project with the Brazos River Authority of Waco, Texas assessing potential ways to mitigate non-point source pollution in the Brazos River. Mr. Norvell has extensive international experience including work with the United States Agency for International Development in Indonesia and the United States Army.

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Gregory A. Porter

M.S. Applied Statistics, Purdue University, West Lafayette, Indiana

B.S. Statistics, University of Rochester, Rochester, New York

Mr. Gregory A. Porter earned his Bachelor's and Master's in statistics from the University of Rochester and Purdue University, respectively. As a research analyst with PMCL, he has focused upon developing water demand analyses for the American Water Works Association Research Foundation, San Diego County Water Authority and the City of San Jose.

In the AWWARF Residential End Use Study, Mr. Porter devised daily water use models for common household enduses such as toilets, clothes washers, and irrigation. For the AWWARF Commercial and Institutional End Use Study, Mr. Porter assisted in the development of daily water use models for five commercial classes (including grocery stores and schools). In addition, he assisted in establishing the first set of benchmarks for efficient water use in each class.

Mr. Porter developed the San Diego County Water Authority's probabilistic water forecast which accounts for uncertainty in data sources and in the modeling process to project municipal and institutional non-agricultural water demands for the Authority and its member agencies in five-year increments from 2000-2030. He is currently working on linking an agricultural water use model to the Authority forecasts.

Terri Thomas

M.S. Geography (in process) Southern Illinois University - Carbondale

B.S. Civil Engineering Technology, Southern Illinois University - Carbondale

Ms. Terri Thomas is an associate research analyst in the Resource Economics and Quantitative Analysis program of PMCL and has completed two temporary assignments with the U.S. Army Corps of Engineers Institute for Water Resources Navigation Analysis Division. Ms. Thomas has conducted research regarding the navigation industry and waterborne commerce. She has prepared information papers on *Maritime Stakeholders*, the *Container Industry*, and on *Future Port Developments for U.S. and Significant Foreign Container Ports*. These papers provide information for The National Dredging Needs Study of Ports and Harbors of the United States. She has reviewed the methodology used to estimate the 1996 revenue projections of the proposed Harbor Services User Fee (HSUF), evaluated vessel movements that could potentially divert from U.S. ports to avoid assessment of the HSUF and estimated the rate schedule to generate projected revenues.

Satisfied clients are long-term clients. PMCL takes great pride in providing innovative, high quality products within time and budget requirements. We offer the following clients as references of our past performance. A check with these clients will reflect our belief – that PMCL is proud of the high degree and professional level of work we have performed in the past and are currently performing.

REFERENCES

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CLIENT LIST

American Water Works Association Research Foundation
Apogee Research, Inc., Bethesda, Maryland
Big Bend Water District, Laughlin, Nevada
Black and Veatch Engineers, Phoenix, Arizona
California Urban Water Agencies, Sacramento, California
Camp Dresser and McKee, Inc., Ft. Myers, Florida
City of Albuquerque, New Mexico
City of Boulder City, Nevada
City of Henderson, Nevada
City of North Las Vegas, Nevada
City of Tampa Water Department, Tampa, Florida
City Water, Light & Power, Springfield, Illinois
CH2M-Hill, Albuquerque, New Mexico
CH2M-Hill, Raleigh, North Carolina
Eugene Water and Electric Board, Eugene, Oregon
Illinois Department of Conservation, Springfield, Illinois
Illinois Department of Transportation, Division of Water Resources, Chicago, Illinois

Indianapolis Water Company, Indianapolis, Indiana
Las Vegas Valley Water District, Las Vegas, Nevada
Lee County Regional Water Supply Authority, Ft. Meyers, Florida
Marin Municipal Water District, Corte Madera, California
Massachusetts Water Resources Authority, Boston, Massachusetts
Metropolitan Water District of Southern California, Los Angeles, California
National Council on Public Works Improvement, Washington, D.C.
New Mexico Joint Powers Agreement Committee, Las Cruces, New Mexico
New York Department of Environmental Conservation, Albany, New York
Orange Water and Sewer Authority, Carrboro, North Carolina
Phoenix Water and Wastewater Department, Phoenix, Arizona
Pinellas County Water System, Clearwater, Florida
Roberts Company, Inc., Carmel, California
Rockwell International, Richland, Washington
San Diego Data Processing Corporation, San Diego, California
San Diego County Water Authority, San Diego, California
South Florida Water Management District, West Palm Beach, Florida
Southern Nevada Water Authority, Las Vegas, Nevada
Southwest Florida Water Management District, Brooksville, Florida
United States Department of the Interior, Geological Survey, Reston, Virginia
United States Water Resources Council, Washington, D.C.
U.S. Army Corps of Engineers, Albuquerque District, Albuquerque, New Mexico
U.S. Army Corps of Engineers, Baltimore District, Baltimore, Maryland
U.S. Army Corps of Engineers, Institute for Water Resources, Fort Belvoir, Virginia
U.S. Army Corps of Engineers, Los Angeles District, Los Angeles, California
U.S. Army Corps of Engineers, Louisville District, Louisville, Kentucky
U.S. Army Corps of Engineers, Mobile District, Mobile, Alabama
U.S. Army Corps of Engineers, Office of the Assistant Chief of Engineers, Washington D.C.
U.S. Army Corps of Engineers, St. Louis District, St. Louis, Missouri
U.S. Army Corps of Engineers, Tulsa District, Tulsa, Oklahoma
U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, Mississippi